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(54) Photomultiplier

(57) In a photomultiplier the secondary emitting surface of the last dynode is distorted to increase its surface area. This is particularly applicable to unfocussed photomultipliers, and counters changes in gain of the final dynode. Alternative forms of distortion, and dimensions, are specified, and techniques of fabrication, such as chemical etching, exemplified.

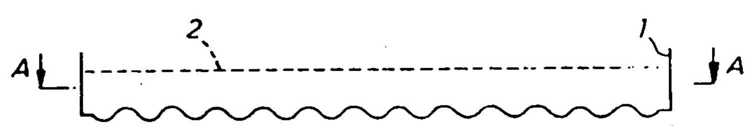

FIG.1

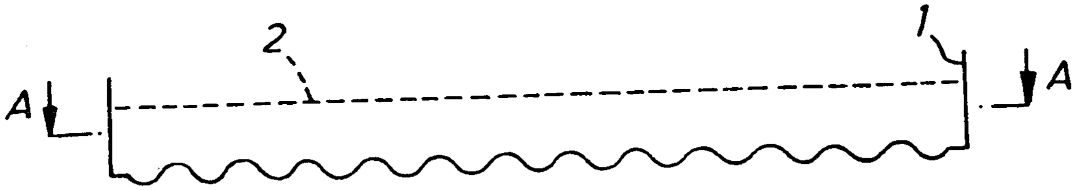

FIG. 1

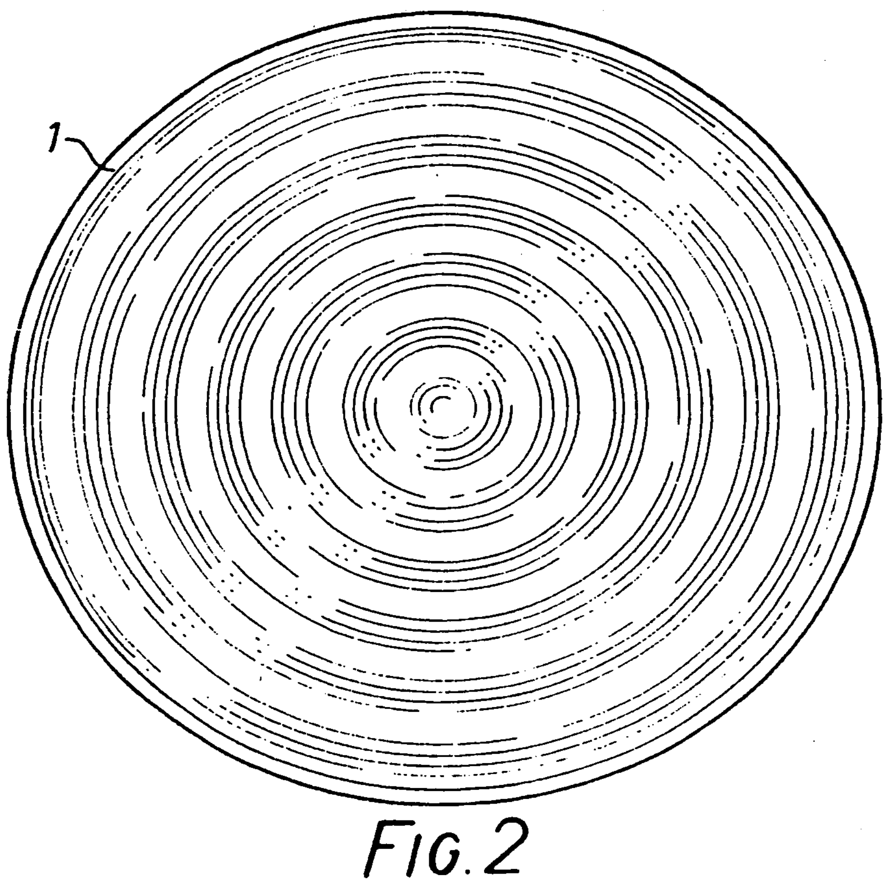

FIG. 2

FIG. 3

SPECIFICATION

Crinkled last dynode to increase ff ctive area

This invention relates to photomultipliers.

Particularly when the anode current is relatively high in a photomultiplier, i.e. of the order of several micro-amps, it is found that the gain of the last dynode may be reduced after long continuous running. A further disadvantage which is sometimes encountered, is that the short term stability of the photomultiplier is not particularly good, that is to say, the overall gain changes during the first few hours of running. It is thought that both of these difficulties, which occur particularly in photomultipliers wherein the active substance is a caesium compound, is due to the fact that the caesium atoms are relatively lightly absorbed on their substrate and may be driven off when relatively large currents are used.

It is an object of this invention to overcome the above-mentioned difficulties.

Accordingly, we provide a photomultiplier in which the secondary emitting surface of the last dynode is distorted from a flat or uniformly curved shape to such an extent that the effective area of said surface is substantially increased without, in operation, substantially affecting the uniformity of the electrical field between said surface and the collector. The photomultiplier may have caesium as an active substance.

The present invention is particularly applicable to those photomultipliers having a construction of the unfocussed type. Two particular such types are the so-called venetian blind structure and the box and grid structure. In both of these types the last dynode is traditionally a flat plate which often forms the bottom of a box across the central or upper part of which is stretched the collecting anode.

The distortion of the receiving surface of the last dynode may be of any convenient type which it is easy to produce by methods of mechanical forming. For example, in the case of a circular flat plate a series of concentric ripples may be produced on the plate. Alternatively, the plate may be embossed. The distortions may be limited to one particular linear or angular direction in the dynode; for example, they may take the form of straight or concentric lines on the dynode or they may be formed in two or more directions simultaneously.

When mechanical forming techniques are used, it is generally more convenient to distort the whole of the plate, but other techniques, such as chemical etching, may be used, and in these cases normally only the secondary emitting surface of the dynode would be distorted. In order that the field produced by the emitted secondary electrons should retain substantial uniformity, it is preferred that the angle between a tangent to the distorted surface at any given point and the plane of the general surface of the dynode, as hereinafter described, at this point is no greater than 60°. By the general surface of the dynode we mean the surface which would have been formed by the dynode had it not been distorted.

In order to satisfy the condition set out above, namely that in operation the electric field between the distorted surface of the dynode and the collector remains substantially uniform, whilst still effectively increasing the dynode surface area preferably the ratio of the peak to peak departure of the distorted surface from the general surface of the dynode, as hereinbefore described, to the separation of that general surface from the collector should everywhere be less than 0.75 but greater than 0.05. In a typical example, the peak to peak departure of the distorted surface from the general surface may lie between 1 and $1\frac{1}{2}$ mm and the separation of the general surface from the collector may be between 2 and 3 mm.

A particularly useful form of distortion, since it is easy in practice to produce, is that of concentric ripples or crinkles.

Having generally described the invention, a specific embodiment will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a cross-section through the last dynode and collector of a venetian blind type photomultiplier,

Figure 2 is a plan view on line A—A of Figure 1, and

Figure 3 is a cross-section through an alternative embodiment.

In Figures 1 and 2 a last dynode of generally box structure 1 is shown in which the originally flat circular plate of the dynode has been formed into a series of concentric ripples. A collector anode 2, insulated from the dynode 1, is also shown in Figure 1. Figure 3 shows a similar structure in which the distortions are in the form of straight-sided pyramids of 60° angle.

An arrangement of the type shown in Figures 1 and 2 has the effect of increasing the surface area of the last dynode by about 40%. Although it is harder in practice to achieve, a pyramidal distortion, as shown in Figure 3, is to be preferred, since the surface area is effectively increased by 100%.

CLAIMS

1. A photomultiplier in which the secondary emitting surface of the last dynode is distorted from a flat or uniformly curved shape to such an extent that the effective area of the said surface is substantially increased without, in operation, substantially affecting the uniformity of the electric field between said surface and the collector.

2. A photomultiplier according to Claim 1 having caesium as an active substance.

3. A photomultiplier according to Claims 1 and 2 wher in the construction is of the unfocussed type.

4. A photomultiplier according to Claims 1 to 3 wherein the distortion is produced by methods of mechanical forming.

5. A photomultiplier according to Claims 1 to 4 wherein the distortion is produced by embossing.

6. A photomultiplier according to Claims 1 to 3

wherein the distortion is produced by chemical etching.

7. A photomultiplier according to Claims 1 to 6 wherein the distortion is limited to one particular linear or angular direction.

8. A photomultiplier according to Claims 1 to 6 wherein the distortion is limited to two or more directions.

9. A photomultiplier according to Claim 7 or 8 wherein the distortion takes the form of straight or concentric lines.

10. A photomultiplier according to any one of the preceding claims wherein the angle between a tangent to the distorted surface at any given point and the plane of the general surface of the dynode, as hereinbefore described, at this point is no greater than 60°.

11. A photomultiplier according to Claims 1 to 10 wherein the last dynode is a circular plate and the distortion takes the form of concentric ripples or crinkles.

12. A photomultiplier according to any one of the preceding claims wherein the ratio of the peak to peak departure of the distorted surface from the general surface of the dynode, as hereinbefore described, to the separation of that general surface from the collector is everywhere less than 0.75 but greater than 0.05.

13. A photomultiplier substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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